COMPARISON OF PREDICTED DELAY TO OBSERVED DELAY

By :

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Abstract

A study has been carried out to compare the observed and predicted capacities and delays at two urban major/minor 3-arm Priority junctions. The capacities and delays were predicted using PICADY2, a computer program to model capacities, queues and delays at such junctions.

PICADY2 predicted the relationship between the controlling flow on the main road and the entry capacity of the minor road as well as the delays for non-priority streams. It was found that there were differences between the observed and predicted capacities and delays when the traffic flows were high i.e. during the peaks, but when traffic flows were lower at the beginning of the evening peak periods, there was good agreement. The reason for the differences between the observed and predicted were examined and it was concluded that the main reasons were :

1. *The vehicle arrivals, particularly on the major road, were not randomly distributed as assumed in PICADY2.*
2. *The priority streams experienced delays, a situation not allowed for in PICADY2.*

In conclusion it has been shown that in urban areas where traffic cannot be assumed to be randomly distributed, the PICADY2 is not a good prediction of delays on the minor road.

Introduction

The most common form of junction control is three-arm major/minor Priority junction. It is very important to provide sufficient capacity for the minor traffic to prevent delays. Delays influence the route choices, time savings and determine the economic appraisal of junction improvement or development. Therefore, it is useful to be able to predict capacities and delays.

PICADY2 has been developed by MVA Systematica under contract to RRL to predict capacities, queues and delays for a wide range of circumtances including theree-arm major/minor Priority junctions.

The capacities were predicted using formulae derived empirically by Kimber and Coombe (1990). These formulae develop the stream capacities as explicit functions of the controlling major road flows and the junction geometric features.

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The associated queues and delays were predicted by theoretical formulae developed by Kimber and Hollis (1979) based on time dependent queueing theory.

This study attempts to compare the results predicted by PICADY2 with those observed and to explain the reasons for the similarities and differences.

A Riview of PICADY2

Introduction. PICADY2 is a computer program which predicts capacities, queues and delays at major/minor Priority junction.(5) This program is useful for assessing design options for new junctions as well as modifications to existing ones. The program is, however, intended as an aid in junction design and is not intended to cover all design aspects.(5)

Theoretical Basis of PICADY2. Of the six separate traffic and associated flows at a three-arm major/minor junction (see figure 1), the two straight-through major road traffic stream C-A and stream A-C are assumed to not suffer any delay because they have uninterrupted priority. The two minor road

streams B-C and B-A as well as the major road right turning stream C-B may experience delay because they have to give way to other streams.

The capacity it predicted using methods developed by Kimber and Coombe by considering the effects of the controlling traffic flows and the geometric layout features[6].

The program predict the vehicle delay using an approximation method. This gives similar results to the direct application of time-dependent queueing theory based on probabilistic theory. The method was developed by Kimber R.M. and Erica M. Hollis[7].

Data Collection

Method of Data Collection. There are two kinds of data which have to be collected namely traffic data and junction geometric features. Traffic data consists of stream traffic flows, percentage of heavy vehicles, and queue lengths, whereas junction features consists of lane widths and visibility distances.

Junction geometric features are, of course, obtained by direct measurement at the sites.

Traffic flow data was obtained using video recording by taking into account the need to :

1) keep the manpower requirement as small as possible,
2) have permanent record of the data, and directly linked to time.

The delay was obtained using "manual-actual queue length short time interval".

Description of The Chosen Junctions. It was important that the chosen junction sites should satisfy certain criteria. The main criteria are set out below.

1. The junctions should have continuous (or near continuous) delay on the minor road approach for a considerable amount of the study period.
2. The sites should provide good views of the junction so that the data collected is suitable enough for analysis.
3. Ideally, the camera position should be capable of measuring the queue length for as much the selected time period as possible, as well as the vehicle turning movements.

From a consideration of the criteria set out above, two junctions were chosen. Both were 3-way junctions, namely :

1) The Meanwood Road (major)/Cross Chancellor Street (minor)
2) The Meanwood Road (major)/Oatland Road (minor).

Times of Data Collection. From an initial inspection of the two junctions, it was clear that traffic queue conditions only occured during the evening peak period.

Method of Analysis

Method of Analysis Using PICADY2. According to TA 20/81 and TA 23/81[6+11], the measurement of the geometric features of the 3-arm major/minor junctions is summarised in Figure 2.

Traffic flow data was obtained by dividing the traffic movements into six different streams. The number of light and heavy vehicles for each traffic movement was counted and recorded during five minute intervals. After being abstracted, traffic flow data and geometric features data were input into PICADY2.

Calculation of Observed Delay and Capacity. Since it was not practicable to record the number of vehicles queueing continously, this was carried out at fixed intervals of time. The time interval had to be short enough to follow the vehicle trend reasonably closely but long enough to enable the observer to count and record the number accurately. A reasonable interval for recording the number of queueing vehicles was consedered to be 30.

An observer equipped with a stop watch and a recording board noted the number of queueing vehicles at 30s intervals. The number was counted using a hand tally and the cumulative vehicle count is usually copied from the hand tally every five minutes.

The delay suffered during the time interval by all the vehicles which were queueing during that time was obtained using equation below.

$$\text{Delay} = \Sigma^{n} Q_i \times t \qquad \text{(vehicle minutes)}$$

where :

Q_i : queue length at the end of the specified time interval i

t : time interval (30 s)

n : number of 30s time intervals in the time period.

To determine the capacity of the non-priority traffic streams, continuous queues are required. It was found, however, that continuous queues only occured for the minor road left-turning traffic stream (q_{BC}) at the two junctions. Therefore, it was decided to consentrate on determining the capacity of left-turning stream (q_{BC}) only for the two junctions.

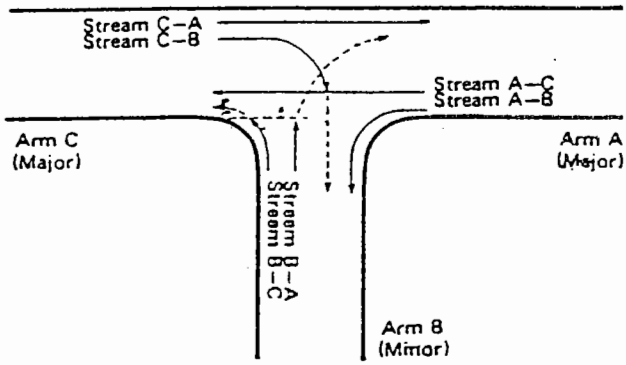


Figure 1. **Traffic Movements at a Three-arm Major/Minor Junction**

Results and Discussion of Results

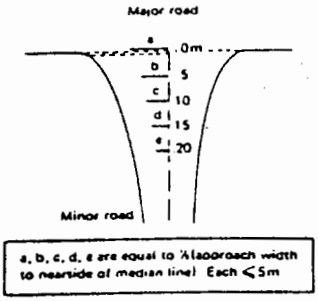
The delays and capacities predicted using PICADY2 and those observed are set out in Tables 1, 2, 3, and 4.

Table 1. **Capacity of left turn stream BC at the Meanwood road/cross chancellor street junction and the Meanwood road/oatland road junction (vehicles/minute)**

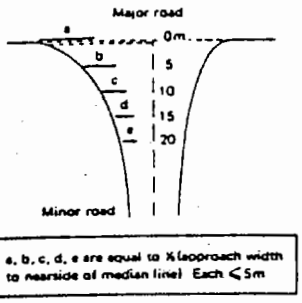
Time Ending	Meanwood/ C. Chancellor		Meanwood/ Oatland, dry		Meanwood/ Oatland, wet	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
1620	9.2	8.92	9.00	6.23	6.00	5.76
1625	8.1	8.22	8.00	6.66	5.80	5.60
1630	7.7	8.60	8.00	6.59	6.00	5.85
1635	7.0	7.05	7.00	6.08	6.25	6.30
1640	6.0	6.67	8.00	4.14	3.47	3.40
1645	6.3	6.27	7.20	3.72	3.80	3.77
1650	6.2	6.99	8.10	5.04	3.80	3.87
1655	4.0	6.58	6.80	3.29	3.80	5.07
1700	6.2	5.35	5.70	4.12	5.00	5.38
1705	4.8	6.11	4.70	3.42	5.90	3.20
1710	6.4	5.06	5.60	1.68	3.40	3.60
1715	3.2	4.24	5.60	3.70	5.00	4.13
1720	5.4	5.01	5.10	3.49	5.00	3.06
1725	4.0	4.62	4.20	2.78	4.80	3.25
1730	5.0	5.77	3.80	2.24	3.40	2.53
1735	3.6	5.22	5.00	2.91	2.60	2.79
1740	4.8	4.84	5.10	3.01	2.80	3.86
1745	4.2	5.21	6.20	2.84	3.60	3.46

Table 2. **Delays for an assumed combined traffic stream (B-AC) in the stated 5 minute time intervals at the Meanwood road/cross chancellor street and Meanwood road/oatland road junctions (vehicle minutes)**

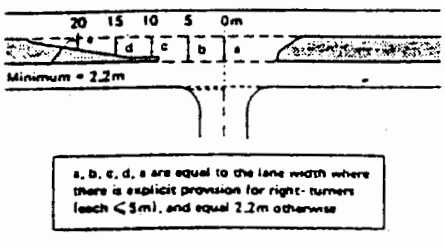
Time Ending	Meanwood/ C. Chancellor		Meanwood/ Oatland, dry		Meanwood/ Oatland, wet	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
1620	4.60	4.60	3.10	3.00	2.90	2.90
1625	10.25	5.20	8.25	2.40	11.50	5.90
1630	9.50	5.30	5.75	2.10	10.25	4.20
1635	10.00	7.70	5.50	2.60	9.25	5.00
1640	17.25	10.20	19.75	4.90	16.00	7.10
1645	17.75	11.30	46.75	8.80	12.75	7.60
1650	14.75	11.80	42.00	4.70	7.25	7.50
1655	30.25	7.30	30.75	17.50	11.50	5.90
1700	69.25	16.20	23.75	14.50	9.00	4.10
1705	94.75	13.50	8.75	9.00	10.25	5.80
1710	97.75	23.00	26.25	15.50	18.75	9.10
1715	91.00	15.90	47.75	29.90	29.75	10.20
1720	83.25	12.40	32.25	18.70	37.25	20.30
1725	83.75	14.80	12.75	8.40	29.00	17.40
1730	76.25	14.00	21.25	13.10	25.25	13.50
1735	67.00	11.90	38.25	19.70	36.25	12.70
1740	76.50	12.80	27.75	14.70	50.25	12.60
1745	83.50	15.10	12.00	12.50	40.25	11.60



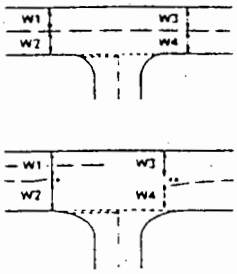
Lane width measurements for the right-turning minor road stream (w_{B-A}, w_{D-C})

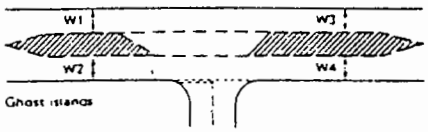


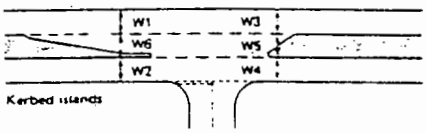
Lane width measurements for the left-turning minor road stream (w_{B-C}, w_{D-A})



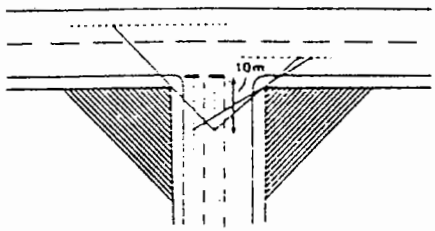
Lane width measurements for the right-turning major road stream (w_{C-B}, w_{A-D})







Components of major road width (W) and central reserve width (W_{CR})



Measurement of visibility distances (V_L and V_r)

Figure 2. **Measurements for the Geometric Features of a Junction**

Table 3. **Delays in stated five minute time intervals at the Meanwood road/cross chancellor street junction (vehicle minutes)**

Time Ending	Stream BC		Stream BA		Stream CB	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
16.20	5.25	4.60	1.25	0.90	2.50	2.20
16.25	6.75	5.30	3.50	1.00	2.25	2.33
16.30	5.75	5.40	3.75	1.00	2.25	2.40
16.35	6.55	7.40	3.50	1.80	2.50	4.00
16.40	13.00	10.40	4.25	2.50	3.25	3.40
16.45	15.00	11.70	2.75	3.00	3.75	4.40
16.50	13.20	12.20	1.50	3.30	4.25	4.80
16.55	29.70	7.20	0.50	2.00	8.50	4.30
17.00	69.20	17.00	0.00	5.60	10.70	5.30
17.05	94.20	17.20	0.50	5.10	9.00	3.20
17.10	96.20	27.80	1.50	7.60	9.25	6.10
17.15	90.00	26.60	1.00	8.80	9.25	4.90
17.20	83.20	19.00	0.00	8.30	14.70	4.80
17.25	81.50	23.00	2.25	8.80	15.70	3.40
17.30	73.70	22.20	2.50	7.70	7.50	3.10
17.35	65.50	16.00	1.50	5.60	3.50	3.80
17.40	75.20	16.20	1.25	5.80	4.50	4.20
17.45	75.20	20.20	8.25	7.40	12.00	3.60

Table 4. **Delays in stated five minute time intervals at the Meanwood road/oatland road junction (vehicle minutes) under dry condition**

Time Ending	Stream BC		Stream BA		Stream CB	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
16.20	2.50	2.40	0.75	1.80	1.50	1.70
16.25	2.50	2.10	1.25	1.60	1.25	1.40
16.30	3.25	1.80	2.50	1.50	1.00	1.50
16.35	2.50	1.90	3.00	1.90	1.25	2.10
16.40	8.00	3.70	11.70	4.30	2.75	3.70
16.45	18.00	12.90	28.70	9.00	6.50	2.80
16.50	16.50	7.10	25.50	5.00	5.75	1.90
16.55	20.20	23.80	10.50	12.80	1.25	2.00
17.00	18.50	40.40	5.25	20.90	0.75	1.80
17.05	6.00	35.30	2.75	20.60	1.25	1.80
17.10	24.20	43.20	2.00	24.20	3.00	2.80
17.15	43.20	74.30	4.50	36.40	2.50	1.80
17.20	26.50	91.30	5.75	42.80	0.50	1.70
17.25	9.00	83.00	3.75	39.30	2.00	1.80
17.30	18.50	84.90	2.75	40.20	2.00	2.20
17.35	35.70	101.10	2.50	46.80	1.50	1.80
17.40	24.50	106.80	3.25	50.60	2.00	2.20
17.45	9.75	105.70	2.25	50.90	1.75	1.70

In examining delay, it is very important to look at the capacity because delay is influenced by the ratio between traffic flow to its capacity.

PICADY2 predicts the relationship between the main road controlling traffic flow (AC) and the capacity of minor road left turn traffic stream BC as a linear function. From Table 1 it is apparent that the observed capacities are slightly lower than those predicted. The PICADY2 program overestimates the capacity of stream BS possibly because the Meanwood Road/Cross Chancellor Street junction provides a wide major road and very good visibility from the minor road. From observation of the video film other possible causes are that some vehicles do not accept adequate gaps to enter the main road and the major straight-through traffic stream AC fives way to the minor road traffic and creates a queue on the main road.

Since the observed and predicated capacities are different, the delays observed and those predicted are not similar.

The PICADY2 assumes that only three of the six separate traffic streams incur delay, i.e. the two minor road streams BC and BA and the major road right-turning streams CB. At the site, however, it was found that the straight-through major road stream AC also experienced delay since this traffic either stopped or adjusted their speed and hence their headways to allow minor road vehicles to enter.

It is also assumed by PICADY2 that the arrival of vehicles on the junctions approaches follows a random distribution. This assumption is different from the reality on the site where the surrounding areas consits of industrial premises with specific finishing time. The differences are also influenced by the presence of the signalized junction.

According to Graham and Chenu[3], platoons do not remain in a compact state but tend to diffuse as they move away from the point of formation.

Estimates of the percentage of the original number of vehicles remaining in the platoon at various distances along the road from the point of origin is shown in Table 5.

Whether or not a minor road vehicle enters a junction depends on the gap of the major road traffic avaible. Major and Buckley[3] developed a relationship between the size of headway and the number of vehicles which can enter the headway from the minor road.

The relationship between the size of headway and the number of vehicles which enter the headway from the minor road is set out in Table 6.

Table 5. **Percentage of vehicles remaining in a road traffic platoon at varying distances from point of formation (Source : Graham and Chenu[3])**

Distance (miles)	Vehicles Remaining in Platoon (%)
0,25	91
0,50	85
0,75	80
1,00	77

Table 6. **Relationship between headway size and the number of vehicles entering (Source : Major and Buckley[3])**

Size of Headway	Number of Vehicles Entering Headways
τ	0
$\tau - 2\tau$	1
$2\tau - 3\tau$	2
$3\tau - 4\tau$	3
etc.	

where τ: a minimum major street headway (s) accepted by a minor road vehicle.

The distances of a priority junction from a signallized junction influences the major road headway distributions and determinies the number of minor road vehicles which can enter the gap.

The distribution of the major road headways is also unfluenced by the behaviour of the drivers, for instance : the major road drivers stopped or adjusted therir headways to allow the minor road vehicles to enter, a circumstance not allowed for in the PICADY2.

The delays experienced by the non-priority stream depends not only on the distribution of the major road traffic headways but also on the distribution of the minor road traffic arrivals. The rules governing the interactions of more than two streams, however, are not clear[8].

Another possible reason for the differences between observed delays and those predicted is the accuracy of observed delays. At peak times, the minor road queue was very long so that a vehicle joined the queue a long way back from the junction approach. Occasionally, the time period of 30s was too short to count the queue length and hence some queue lengths were recorded inaccurately. It was also found difficult sometimes to judge exactly when a vehicle joined the queue.

A problem was encountered when distinguishing between stream BC and stream BA since it was difficult to know whether a vehicle would turn right or turn left when it was in the queue. Therefore, when minor road delays were divided into two groups i.e. streams BC and BA, the differences between the observed and predicted delays were high. On the other hand, the differences became smaller when the two streams were combined.

Conclusion

The conclusions of this study are set out below.

1. PICADY2 assumed that only three of the six separate traffic streams incur delay, namely the two minor road streams BC and BA and the major road right-turning stream CB. At the two selected sites, however, it was found that the straight-through major road stream AC also experienced delays because the drivers of this traffic either stopped or adjusted their headway to allow minor road vehicles to enter.
2. PICADY2 assumes that traffic arrivals are randomly distributed. Because of the presence of a signalized junction nearby and the finishing time of the industries at surrounding areas, the traffic arrivals were not randomly distributed.
3. Compared with the capacities observed, the predicted capacities were higher for the Meanwood Road/Cross Chancellor Street junction but lower for the Meanwood Road/Oatland Road junction. The reasons for the differences were :
   a) the geometric geatures of the two junctions were different. The Meanwood Road/Cross Chancellor Street junction has wider roads and better visibilites.
   b) the behaviour of the drivers was different in terms of the running speed and the will to give way to the minor road drivers.

c) the headway distributions of the major road traffic of the two junctions were also different.

4. When it was assumed that there were two turning streams on the minor road approach B, the difference between the observed and predicted delays was very high. This difference became smaller when it was assumed that there was only shared stream catering for both the left and right turners. The reason for this is that the single lane assumption more accurately represents the actual site situation at both junctions.
5. Generally, when traffic flows were low, PICADY2 could predict actual capacities and delays accurately.

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